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Proton Magnetic Resonance Investigation of Inversion at Tervalent Nitrogen, 6[1]

Preparative Separations of Enantiomeric Diaziridines by Liquid Chromatography on Triacetylcellulose. Racemizations Monitored by Polarimetry and by ^{1}H NMR

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Enantiomeric diaziridines have been partially separated by chromatography on triacetylcellulose. (−)-**2**, (+)-**4**, and (−)-**4** were obtained almost pure, enantiomeric purities (Table 1) being measured by ^{1}H NMR in the presence of optically active additives. The same procedure was tested for monitoring racemizations (Table 2) which were also studied, with higher accuracy, by polarimetry. The barriers to nitrogen inversion, converting the *trans*-diaziridines **2** and **4** into *cis*-intermediates, are compared with known ΔG^* values.

Protonenresonanz-Untersuchungen zur Inversion am dreibindigen Stickstoffatom, 6[1]

Präparative Trennungen enantiomerer Diaziridine durch Flüssigkeits-Chromatographie an Triacetylcellulose. Verfolgung der Racemisierungen mittels Polarimetrie und ^{1}H-NMR

Enantiomere Diaziridine ließen sich durch Chromatographie an Triacetylcellulose anreichern. (−)-**2**, (+)-**4** und (−)-**4** wurden fast rein erhalten, wobei die enantiomeren Reinheiten (Tab. 1) mittels ^{1}H-NMR in Gegenwart optisch aktiver Zusätze bestimmt wurden. Dasselbe Verfahren wurde im Hinblick auf die Verfolgung von Racemisierungen (Tab. 2) erprobt, welche mit höherer Genauigkeit außerdem mittels Polarimetrie studiert wurden. Die Schwellen der Stickstoff-Inversion, welche die *trans*-Diaziridine **2** und **4** in *cis*-Zwischenstufen überführt, werden mit bekannten ΔG^*-Werten verglichen.

Diaziridines are one of the classes of compounds for which the barrier to inversion at tervalent nitrogen is increased considerably by stereoelectronic and inductive effects[4,5]. It was predicted[4] that the invertomers of *trans*-diaziridines can be preparatively separated. Such separations have been accomplished for diastereomers[6–10] like (1*R*, 2*R*, 3*S*)- and (1*S*, 2*S*, 3*S*)-**1**[11]. However, enantiomers, e.g. (1*R*, 2*R*)- and (1*S*, 2*S*)-**2**, would be of more interest in this respect because of their unknown chiroptic properties and since their interconversion by two consecutive nitrogen inversions[7] occurs between two isoenergetic ground states, whereas the details of the equilibration kinetics[7] for diastereoisomeric diaziridines are more complicated.

The enrichment of enantiomers[10] *via* diastereomeric salts of optically active acids has not yet been achieved[8,12]. In two cases, *Kostyanovskii* and his group[13,14] have

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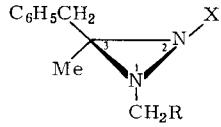
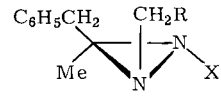
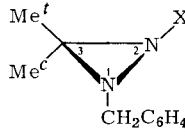
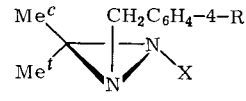


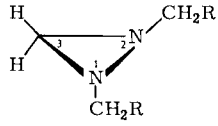


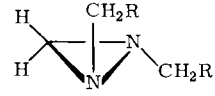
	R	X	
(1*R*, 2*R*, 3*S*)-**1**	C_6H_5	CH_3	(1*S*, 2*S*, 3*S*)-**1**
(1*R*, 2*R*)-**2**	H	CH_3	(1*S*, 2*S*)-**2**
(1*R*, 2*R*, 3*S*)-**3**	H	H	(1*S*, 2*S*, 3*S*)-**3**





	R	X	
(1*R*, 2*R*)-**4**	H	H	(1*S*, 2*S*)-**4**
(1*R*, 2*R*)-**5**	OCH_3	H	(1*S*, 2*S*)-**5**
(1*R*, 2*R*)-**6**	H	CH_3	(1*S*, 2*S*)-**6**





(1*R*, 2*R*)-**7**	R = $CH_2C_6H_5$	(1*S*, 2*S*)-**7**
(1*R*, 2*R*)-**8**	R = $C(CH_3)_3$	(1*S*, 2*S*)-**8**

obtained slight kinetic enrichments; for a further enantiomeric diaziridine[14] a purity of 63.5% was attained after additional separation by means of a derivative of chloral. Recently, the above investigators have prepared both enantiomers of 3,3-bis(methoxycarbonyl)-1-methyldiaziridine[15] in high enantiomeric purity *via* the diastereomeric salts of 3-carboxy-3-methoxycarbonyl-1-methyldiaziridine with an optically active amine. Both approaches, however, need special functional groups (NH and CO_2H, respectively) in the diaziridine molecule. Therefore, we tried an alternative method for the separation of enantiomers: Liquid chromatography on swollen microcrystalline triacetylcellulose according to *Hesse* and *Hagel*[16]. Apparently[16,17], this is a versatile technique which does not depend very strongly upon the presence or absence of special functional groups, although a monosubstituted benzene ring seems to favour the separation.

The barriers to inversion in diaziridines[7] are of interest for the study of substituent and medium effects. Particularly, the influence of a complexing auxiliary compound upon the barrier in a substrate molecule should be tested[18] because such compounds, if optically active, may be used for the measurement of the relative amount of enantiomers[1,7].

Some $\Delta G^{\neq}$-values[6-9] for inversions, measured by NMR of equilibrating diastereoisomers, by NMR signal coalescence, or by polarimetry, are known, including $\Delta H^{\neq}$ and $\Delta S^{\neq}$ values in a single case[7]. However, the true[7] inversion barrier for each particular nitrogen atom in a *trans*-diaziridine molecule could mostly not be given from the overall $\Delta G^{\neq}$ value measured. Therefore, further results, especially of simple systems, are needed for a detailed understanding of the effects.

Separations of Enantiomeric Diaziridines by Liquid Chromatography on Triacetylcellulose

The prospect of success for a preparative separation was assessed from analytical chromatograms (e.g. Fig. 1) of diaziridines (±)-**2** and (±)-**4** through (±)-**8**. The chromatograms of **2**, **5**, and **8** were similar to Fig. 1, **2** and **8** showing somewhat reduced separations[20]. Compound[12] **7** deviates from this behaviour by strong tailing of the chromatographic peaks. Diaziridine **6** apparently has a low specific rotation; therefore, the α/V curve (cf. Fig. 1) differed only weakly from the abscissa.

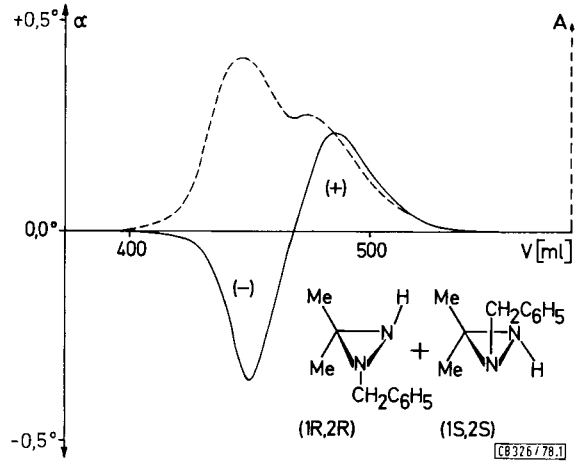


Fig. 1. Analytical chromatogram of 149 mg of (±)-**4** in ethanol/water (96:4) after passing two columns (41 cm length, 2.5 cm internal diameter, 22 °C) of triacetylcellulose (particle size 0.032 to 0.056 mm). α: Rotation angle (———) at 365 nm. A: Absorbance (– – – –) at 257 nm. V: Volume of eluate; injection at V = 0

Our preparative separations were performed by using two equal columns and the known *recycling* procedure which increases the effective column length without increasing the pressure needed. Recycling was combined with *cutting* the eluate into different parts. After the first passage through a column, the front part (approximately 10%) was cut and collected ("early eluate"), whereas the rest of the material was directed to the other column. On each further column passage, further amounts of one enriched enantiomer were obtained. The eluate of the last column passage ("final eluate") was divided into fractions in the usual way. At least some enrichment in solution was attained for each diaziridine enantiomer hitherto tested by us. (+)- and (−)-1-Isopropyl-3,3-dimethyldiaziridine could not be separated from the eluent ethanol because of their

Table 1. Separations by liquid chromatography and properties of enantiomeric diaziridines

Predominant enantiomer	Number of passages (column type)[a]	Eluates used[b]	δ	*b* [Hz]	S Solvent		*P* [%]	$[\alpha]_{365}^{22}$ CCl_4
(+)-**2**		6 early eluates	2.87	1.5			59±3	+151°
	7(A)				3-Me $[D_8]$toluene	0.27		
(−)-**2**		last fractions of final eluate	2.93	1.5			97±3	−245°
(+)-**4**		last fractions of eluate	2.73	2.4			92±3	
	2(B)				3-Me[c] $CDCl_3$	≈0.18		
(−)-**4**		first fractions of eluate	3.09	2.4			93±3	
(+)-**4**		last fractions of final eluate	2.54	5.1			90±3	+345°
	4(B)				3-Me[c] C_6D_6	≈0.22		
(−)-**4**		2 early eluates and first fractions of final eluate	2.98	6.0			75±3	−310°
(+)-**5**	2(B)	last fractions of final eluate	2.03	1.6	3-Me[c] $CDCl_3$	0.17	21±2	+ 72°
(+)-**8**	5(A)	last fractions of final eluate	2.10	0.8	NCH_2N C_6D_6	5.4	18±4	+ 54°

[a] See experiment part. – [b] See text for different eluates.

δ and *b*: ^{1}H NMR shift[22] and linewidth for a signal of the predominant enantiomer in the presence of (+)-Eu(hfbc)$_3$; for **8**, the auxiliary compound was (+)-$C_6H_5CH(CF_3)OH$.
S: Signal chosen[23].
r: Number of equivalents of optically active auxiliary compound.
P: Enantiomeric purity, determined from ^{1}H NMR intensities.

volatility. Table 1 gives some results, indicating the effort required for each separation by stating the number of column passages and the eluates which we used.

The enantiomeric purities[21] (Table 1) were determined by ^{1}H NMR in the presence of optically active auxiliary compounds[7,19], e.g. (+)-tris[3-(heptafluorobutyryl)-D-camphorato]europium(III), (+)-Eu(hfbc)$_3$. Two suitable signals of the enantiomers, e.g. the 3-Me[c] signal of (+)- and of (−)-**4** (Fig. 2), were chosen. Because of some overlap, their relative intensities were obtained by the weights of cut spectrum copies.

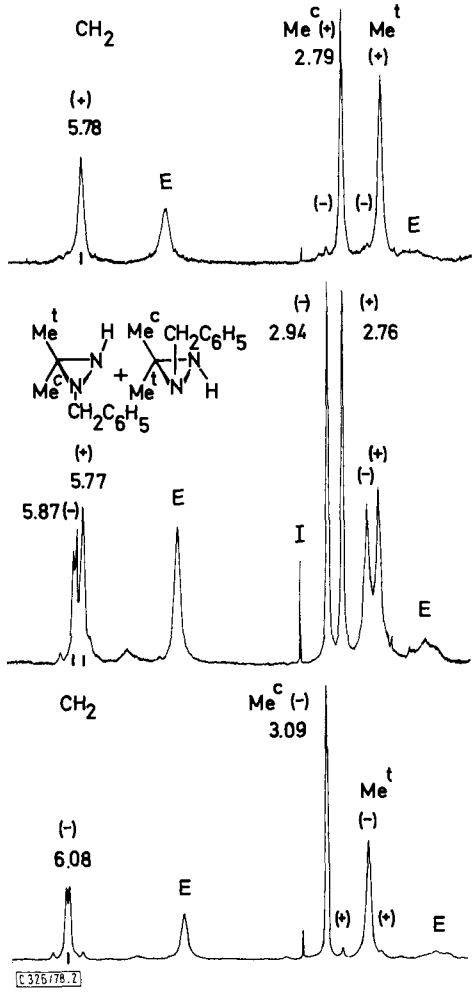


Fig. 2. 90 MHz ^{1}H PFT NMR of CH_2 and Me groups[23] of (+)-**4** (top), (±)-**4** (center), and (−)-**4** (bottom) in $CDCl_3$ at 26 °C. Enantiomeric purities are 87±3% for (+)-**4** and 93±3% for (−)-**4**. ≈0.18 equivalents of (+)-Eu(hfbc)$_3$ are present. E: Protons of (+)-Eu(hfbc)$_3$. I: Unknown impurity. Numbers are δ-values. Spectral width 1200 Hz; 42° pulses; 45 scans

Racemizations of Enantiomeric Diaziridines Monitored by Polarimetry and by ^{1}H NMR

The thermal racemizations of (+)-**2** (P = 59%), (+)-**4** (P = 87%), and (−)-**4** (P = 87%) were monitored by polarimetry during a period of two to four half-lives $t_{0.5}$ (Table 2). These processes were clearly of first order, as expected for intramolecular motions. The final angle of rotation was zero. The errors of the resulting $\Delta G^{\neq}$ values are fairly low due to the high specific rotations of the starting materials (Table 1).

We have assumed[7] that the stereoisomers of a *trans*-diaziridine interconvert by two consecutive nitrogen inversions *via* a *cis*-intermediate. This mechanism is supported by calculations[7] which indicate that the monoplanar transition state for inversion at one nitrogen atom is much lower in energy than the bi-planar transition state for two synchronous inversions. The latter transition state suffers, *inter alia*, from high strain energy caused by the two planar sp^2-hybridized nitrogen atoms. The above mechanism of consecutive inversions requires[6,7] a statistical factor of 0.5 in the calculation of $\Delta G^{\neq}$ for inversion at one nitrogen atom. Therefore this factor has been applied throughout.

Nevertheless, we also tried an alternative, not yet described method which may serve to monitor racemizations: ^{1}H NMR of signal intensities in the presence of an optically active auxiliary compound. For instance, from a solution of (−)-**2** (P = 90%), racemizing at 89.9 °C, 11 sample solutions were withdrawn during a period of 1.5 half-lives at certain times and analyzed by ^{1}H NMR after the addition of 0.27 equivalents of (+)-Eu(hfbc)$_3$. The relative intensities were again determined by the weights of cut spectrum copies. This procedure makes it difficult to calculate the systematic error; the final error was roughly estimated to amount to ±0.6 kJ/mol. The resulting $\Delta G^{\neq}$ = 115.5 kJ/mol (Table 2) closely agrees with the one obtained by polarimetry ($\Delta G^{\neq}$ = 115.4 kJ/mol). The same is true for the racemization of (−)-**4** (Table 2).

Table 2. Racemization data of enantiomeric diaziridines, obtained by simultaneous polarimetry and by ^{1}H NMR of sample solutions withdrawn at certain times

	Solvent	T [°C]	Method	$t_{0.5}$ [a] [min]	$10^4\,k$ [a] [s^{-1}]	$\Delta G^{\neq}$ [b] [kJ/mol]
(−)-**2**	toluene	89.9	polarim., 436 nm	56.9	1.01	115.4±0.2
(−)-**2**	[D_8]toluene	89.9	^{1}H-NMR intens.[c]	60	1.0	115.5[e]
(+)-**4**	toluene	89.9	polarim., 365 nm	18.7	3.09	111.7±0.2
(−)-**4**	toluene	89.9	polarim., 365 nm	16.7	3.45	111.4±0.2
(−)-**4**	C_6H_6	70.1	polarim., 365 nm	174	0.332	111.8±0.2
(−)-**4**	C_6D_6	70.1	^{1}H-NMR intens.[d]	149	0.39	111.3[e]

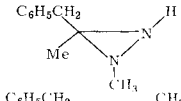
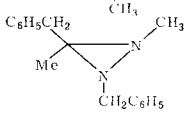
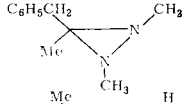
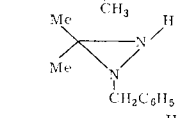
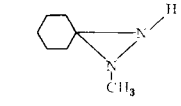
[a] For two consecutive nitrogen inversions, converting the *trans*-diaziridine into the enantiomeric *trans*-diaziridine *via* a *cis*-intermediate (see text).
[b] For a single nitrogen inversion, converting the *trans*-diaziridine into a *cis*-intermediate (see text).
[c] Two 3-Me signals, generated by subsequent addition of 0.27 equivalents of (+)-Eu(hfbc)$_3$ to each of 11 sample solutions.
[d] Two 3-Me^c signals, generated by subsequent addition of ≈0.22 equivalents of (+)-Eu(hfbc)$_3$ to each of 9 sample solutions.
[e] Final error roughly estimated to amount to ±0.6 kJ/mol.

The inherent error and the required effort of this technique would be much smaller, if the racemization were performed *in the presence* of an optically active additive[18]. This turned out to be impossible for **2** and **4** which at 70 °C are slowly decomposed by Eu(hfbc)$_3$. Other auxiliary compounds like (+)-$C_6H_5CH(CF_3)OH$ did not, in these cases, generate sufficient shift differences. Monitoring thermal racemizations by ^{1}H NMR signal intensities may be of interest if the polarimetric angle of rotation is small or if side reactions have to be taken into account. Further racemization methods not using polarimetry are apparently unknown.

The comparison of our barriers to inversion with similar ones shows that the replacement of a methyl group by benzyl (compare the $\Delta G^{\neq}$ values for **1**[11] and **2** as well

as for **3**[11] and **4**) does not generate a significant change (Table 3). The substitution of N–H by N–alkyl (compare the results for **3** and **1** as well as for **4** and **2**) increases the barrier by 3 to 4 kJ/mol, although **9**[8] (Table 3) does not fit completely into these findings. Steric effects in the ground state of inversion or an inductive effect of alkyl vs. hydrogen should bring about an opposite change, if any[5]. Thus, the above increase of the barrier should be the consequence either of some hydrogen bonding in **3** and **4** or of steric effects in a transition state[25]. In principle, N–alkyl inversion and consecutive N–H proton dissociation (or *vice versa*) are not excluded as an interconversion mechanism for the stereoisomers of **3** and **4**. Experiments to decide between these possibilities are in progress.

Table 3. Barriers to nitrogen inversion in diaziridines

	Solvent	T [°C]	$\Delta G^{\ddagger}$ [a] [kJ/mol]
3[7] 	C_2Cl_4	70.0	111.7 ± 0.4[b]
1[7] 	C_2Cl_4	70.0 89.9	114.7 ± 0.4[c] 114.2 ± 0.4[c]
2 	toluene	89.9	115.4 ± 0.2
4 	toluene C_6H_6	89.9 70.1	111.6 ± 0.1 111.8 ± 0.2
9[8] 	C_6H_6	70	115.3

[a] For a single nitrogen inversion, converting the *trans*-diaziridine into a *cis*-intermediate (see text).
[b] Because of the two diastereoisomers of **3**, a mean[7] free enthalpy of activation is given.
[c] The two diastereoisomers of **1** have equal[6,7] free enthalpy, by chance.

This work was supported by *Deutsche Forschungsgemeinschaft* and *Fonds der Chemischen Industrie*. Professor Dr. *G. Hesse*, Erlangen, kindly informed us about the details of his method of separation. Dr. *G. Becher*, Miss *G. Heidelberger*, and Dr. *R. Rauchschwalbe* tested the chromatographic arrangement and suggested improvements. We are grateful to Dr. *T. Burgemeister*, Mr. *H.-H. Henschel*, Dr. *W. A. Herrmann*, and Dr. *J. Wachter* for some spectra.

Experimental Part

Melting points: Büchi SMP 20 instrument, not corrected. – ^{1}H NMR spectra: Varian T-60 (CW mode, 60 MHz) and Bruker WH-90 (PFT mode, 8K data points, 90 MHz) spectrometers, in $CDCl_3$, unless indicated otherwise. – ^{13}C NMR spectra: PFT mode at 22.63 MHz, Bruker WH-90

spectrometer with 8K data points. – UV spectra: Beckman Acta M VI spectrometer. – Specific rotations: Perkin-Elmer 241 electronic polarimeter. – CD spectra: Jasco J-40A instrument, at 22°C. – Low and high resolution mass spectra: Varian MAT-CH5 and Varian MAT-311A spectrometers, respectively, 70 eV, direct insertion probes. – Fractionations under reduced pressure: Spaltrohr column (Fischer, Labor- und Verfahrenstechnik, Bonn-Bad Godesberg).

Liquid chromatography on triacetylcellulose: The separation of enantiomers was performed by column chromatography on swollen, microcrystalline triacetylcellulose[16] as a sorbent (particle sizes 0.056 to 0.071 mm, type A, and 0.032 to 0.056 mm, type B, 22°C) and ethanol/water (96:4) as an eluent. The chromatographic equipment involved: Glass columns of 2.5 × 30 cm (type A columns; Serva GmbH, Heidelberg) and 41 cm (type B columns; Latek GmbH, Heidelberg); UV analyser LKB 8300 Uvicord II; polarimeter Perkin-Elmer 141; fraction collector LKB 2112 Redirac; two-channel recorder Servogor 2S (Goerz Electro GmbH, Wien); membrane pump ProMinent electronic (Chemie und Filter GmbH, Heidelberg; pressure 10 to 11 at).

Analytical chromatograms were obtained by passing a racemate through the system including one or two triacetylcellulose columns. Absorbance and angle of rotation of the eluate were recorded continuously[20] (see Fig. 1).

For preparative chromatography two equal columns were used and the final eluate was divided into different parts by means of the fraction collector. The recycling procedure was applied by performing several passages of the solution through the columns. This was achieved with a manual gauge (Dreh-Probenaufgabe-Ventil, Latek GmbH, Heidelberg) which, in addition, removed a smaller first part of the solution ("early eluate") from the system (cutting), whereas a larger second part was conducted through the other column.

Determination of enantiomeric purity P: The relative intensities of two suitable ^1H NMR signals of the enantiomers in the presence of an optically active auxiliary compound[22] served for the measurements of *P* (Table 1). Spectrum copies were repeatedly cut out and divided into the two components, which were weighed. (+)-Tris[3-(heptafluorobutyryl)-D-camphorato]europium(III), (+)-Eu(hfbc)$_3$, was available from Regis Chemical Co., Morton Grove, Ill., USA, (+)-(*S*)-2,2,2-trifluoro-1-phenylethanol from Burdick & Jackson Laboratories, Muskegon, Mich., USA.

Racemizations monitored by ^1H NMR: A stoppered tube (internal diameter 1 cm) containing the solvent (1.5 ml for (−)-**2** and 2.0 ml for (−)-**4**) was warmed in the ultrathermostat (Colora U3-S8, $\Delta T = \pm 0.1°$) at the desired temperature (see Table 2). The reaction was started by adding a solution (698 mmol of (−)-**2** in 1.5 ml or 275 mmol of (−)-**4** in 1.95 ml) of an enriched enantiomer in the same solvent. Portions of 0.3 ml were drawn out of the solution at suitable time intervals and cooled to 0°C. After addition of (+)-Eu(hfbc)$_3$ ^1H NMR spectra of the 3-Me signals were recorded, cut, and weighed, as above.

Racemizations monitored by polarimetry: 0.025 M solutions containing enriched (−)-**2**, (+)-**4**, or (−)-**4** (Table 2) were set into the 5 cm cell of a Perkin-Elmer 141 polarimeter. The rate was measured directly by plotting the rotation angle *versus* time (determined by chart speed). The temperature ($\Delta T = \pm 0.1°$) of the thermostated cell was read at its inlet and outlet, the mean value being taken as the actual cell temperature. The evaluation of first order rate constants and $\Delta G^{\neq}$ values (Table 2) for both types of racemizations was carried out with the program[26] KIN 3 using the least squares procedure. The calculations were performed on the Siemens TR 440 computer.

(±)-3-Benzyl-1,2,3-trimethyldiaziridine (**2**)[6]: Obtained from benzyl methyl ketone, methylamine, and *N*-methylhydroxylamine-*O*-sulfonic acid[27] according to the general procedure given by *Schmitz* and coworkers[28,29]. Twofold fractionation under reduced pressure, b.p. 43–45°C/0.001 Torr, yielded an oil which crystallized from n-pentane at −30°C: Colourless crystals, m.p. 23–26°C, n_D^{20} 1.5138.

^{1}H NMR (CCl_4, 42°C, 0.29 M): δ = 1.05 (3-Me, s), 2.33 and 2.50 (1- and 2-CH_3, s), 2.67 and 2.80 (CH_2, AB, ^3J = 13.5 Hz), 7.1–7.2 (C_6H_5, m). – ^{13}C NMR (23°C, 0.94 M): δ = 16.9 (3-Me), 39.5 (CH_2), 40.0 and 40.1 (1- and 2-CH_3), 63.9 (C^3, diaziridine ring), 126.3 (C^4, Phenyl ring), 128.4 (C^3, phenyl), 129.4 (C^2, phenyl), 138.1 (C^1, phenyl). – MS, molecular ion: Calc. 176.1313, Found 176.1324.

$C_{11}H_{16}N_2$ (176.3) Calc. C 74.95 H 9.15 N 15.90 Found C 75.02 H 8.75 N 15.64

(+)-and (−)-3-Benzyl-1,2,3-trimethyldiaziridine (**2**): Obtained from 100 mg of (±)-**2** through two columns of type A at a flow rate of 135 ml/h. Altogether seven column passages took place. The six early eluates contained 46 mg of crystalline[30] (+)-**2**, $[\alpha]^{22}_{436}$ = +85 ± 5° (0.350 g/100 ml CCl_4), $[\alpha]^{22}_{365}$ = +151° (0.076 g/100 ml CCl_4), P = 59 ± 3%. The last fractions of the final eluate contained 26 mg of crystalline (−)-**2**, $[\alpha]^{22}_{436}$ = −141 ± 4° (0.050 g/100 ml CCl_4), $[\alpha]^{22}_{365}$ = −245° (0.048 g/100 ml CCl_4), P = 97 ± 3%. CD (n-hexane, 25°C, calc. for P = 100%): λ_{max} = 268 nm ($\Delta\varepsilon$ = −0.12 l cm^{-1} mol^{-1}), 262 (−0.12), 256 (−0.08), ≈219 (≈ +1.6), ≈214 (≈ +1.7).

The ^{1}H NMR spectra were in agreement with the one of (±)-**2**, although they showed ≈2% (by weight) of n-hexane, originating from the eluent.

(±)-1-Benzyl-3,3-dimethyldiaziridine (**4**)[31]: The raw product was purified by fractionation. The main fraction, b.p. 66°C/0.1 Torr, solidified in the refrigerator. After sublimation at 0.2 Torr by gently warming to about 60°C a product of m.p. 36–37°C (lit.[31] 30–32°C) was obtained. It contained a trace of an impurity (Fig. 2).

^{1}H NMR (34°C, 0.18 M): δ = 1.44 (two 3-Me, s), 1.95 (2-H, s, broad), 3.68 (CH_2, s), 7.2–7.4 (C_6H_5, m). – MS, molecular ion: Calc. 162.1157, Found 162.1158. – UV (n-hexane): λ_{max} = 267 nm (shoulder), 264 (ε = 124 l cm^{-1} mol^{-1}), 258.5 (172), 253 (139), 248.5 (shoulder), 214 (3318).

$C_{10}H_{14}N_2$ (162.2) Calc. C 74.03 H 8.70 N 17.27 Found C 74.24 H 8.45 N 17.52

(+)- and (−)-1-Benzyl-3,3-dimethyldiaziridine (**4**): Obtained from 150 mg of (±)-**4** through two columns of type B at a flow rate of 139 ml/h. Altogether, four column passages took place. Two early eluates together with the first fractions of the final eluate contained 29 mg of crystalline[30] (−)-**4**, $[\alpha]^{22}_{436}$ = −180 ± 5° and $[\alpha]^{22}_{365}$ = −310 ± 6° (0.361 g/100 ml CCl_4), P = 75 ± 3%. CD (n-hexane, 25°C, calc. for P = 100%): λ_{max} = 268 nm ($\Delta\varepsilon$ = −0.06 l cm^{-1} mol^{-1}), 262 (−0.06), 255 (−0.04), ≈249 (≈ −0.02), ≈219 (≈ −0.45), ≈214 (≈ −0.85). The last fractions of the final eluate contained 29 mg of crystalline (+)-**4**, $[\alpha]^{22}_{436}$ = +205 ± 3° and $[\alpha]^{22}_{365}$ = +345 ± 5° (0.400 g/100 ml CCl_4), P = 90 ± 3%. CD (n-hexane, 25°C, calc. for P = 100%): λ_{max} = 268 nm ($\Delta\varepsilon$ = +0.05 l cm^{-1} mol^{-1}), 261 (+0.04), 255 (+0.03), 249 (+0.02), ≈219 (≈ +0.30), ≈215 (≈ +0.63). – The ^{1}H NMR spectra were in complete agreement with the one of (±)-**4**.

A similar separation of 150 mg of (±)-**4** yielded 32 mg of (−)-**4**, P = 93 ± 3%, and 38 mg of (+)-**4**, P = 92 ± 3%.

(±)-1-(4-Methoxybenzyl)-3,3-dimethyldiaziridine (**5**)[31]: The raw product was purified by fractionation: Main fraction, b.p. 105°C/0.2 Torr (lit.[31] 114–115°C/0.2 Torr). The final purification was achieved by chromatography on triacetylcellulose (two columns of type B) with ethanol/water (96:4): m.p. 43–44°C.

^{1}H NMR (24°C, 0.07 M): δ = 1.43 (two 3-Me, s), 2.01 (2-H, s, broad), 3.85 and 3.66 (CH_2, AB, ^3J = 13.6 Hz), 3.80 (OCH_3, s), 6.88 and 7.30 (3-/5-H and 2-/6-H on phenyl ring, AA'BB', ^3J = 8.8 Hz, calc. for AB). – MS, molecular ion: Calc. 192.1263, Found 192.1256.

$C_{11}H_{16}N_2O$ (192.25) Calc. C 68.72 H 8.39 N 14.57 Found C 68.69 H 8.26 N 14.75

(+)-1-(4-Methoxybenzyl)-3,3-dimethyldiaziridine (**5**): Obtained by one passage of 43 mg of (±)-**5** through two columns of type B at a flow rate of 66 ml/h. The last fractions of the eluate contained 19 mg of crystalline[30] (+)-**5**, $[\alpha]^{23}_{365}$ = +72 ± 5° (0.209 g/100 ml CCl_4, P = 21 ± 2%).

(±)-1-Benzyl-2,3,3-trimethyldiaziridine (**6**): Prepared from benzylamine, acetone, and *N*-methylhydroxylamine-*O*-sulfonic acid[27] according to the general procedure[28,29]. The raw product was purified by fractionation: Main fraction, b.p. 53–54°C/0.001 Torr. The final purification was achieved by chromatography on triacetylcellulose (two columns of type B) with ethanol/water (96:4).

^{1}H NMR (CCl_4, 34°C, 0.43 M): δ = 1.27 (two 3-Me, s), 2.32 (2-CH_3, s), 3.35 (CH_2, s), 7.0–7.3 (C_6H_5, m). – MS, molecular ion: Calc. 176.1313, Found 176.1308.

$C_{11}H_{16}N_2$ (176.3) Calc. C 74.96 H 9.15 N 15.89 Found C 74.99 H 9.02 N 15.55

(±)-1,2-Dineopentyldiaziridine (**8**): Obtained by condensation of formaldehyde with neopentylamine and addition of sodium hypochlorite according to the general procedure given by *Schmitz* and coworkers[29,32]. The raw product was purified by fractionation: B.p. 27–28°C/0.02 Torr, n_D^{22} 1.4238.

^{1}H NMR (34°C): δ = 0.97 (six Me, s), 1.98 and 2.39 (two CH_2, AB, ^3J = 11.7 Hz), 2.40 (CH_2, diaziridine ring, s). – MS: *m/e* = 184 (8%, $M^{+\cdot}$), 169 (3), 128 (8), 127 (76), 100 (17), 98 (10), 86 (7), 84 (11), 71 (45), 57 (100), 56 (15), 55 (21), 43 (88), 42 (56), 41 (61), 39 (17), 30 (17), 29 (37), 28 (9), 27 (18), 26 (9).

$C_{11}H_{24}N_2$ (184.3) Calc. C 71.68 H 13.12 N 15.20 Found C 71.19 H 13.31 N 14.84

(+)-1,2-Dineopentyldiaziridine (**8**): Obtained from (±)-**8** two columns of type A at a flow rate of 135 ml/h. Altogether five column passages took place. The last fractions of the final eluate contained (+)-**8**, $[\alpha]_{365}^{22}$ = +54 ± 4° (0.453 g/100 ml CCl_4), *P* = 18 ± 4% (determined from ^{1}H NMR integral curves). Some (+)-**8** was lost during removal of eluent because **8** is volatile.

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